IDOC : Integrated Data & Operation Center

- Context
- Ambitions, Strategy, Responsibilities, Budgets
- Projects
- Infrastructure
- Satellite operations
- Mission and processing center
- Access interfaces and virtual observatory
- Certifications and foresight
- IDOC key points
- AOB

Environment : constraints

IDOC .

At the heart

- of the IAS
- the OSU Paris Saclay.
- the P2IO labex.
- Université Paris Saclay

Demanding context of space missions

International consortia

Budgets: Juice mission: > 650 M€.

Majis instrument: > 80 M€

Strong long term commitments

Open Science, FAIR, RDA, VO,...

Interlocutors .

- Other French and foreign space laboratories
- Space agencies: CNES, ESA, NASA, JAXA, CSSAR, FKA,...
- Industrialists in the computer or space sector

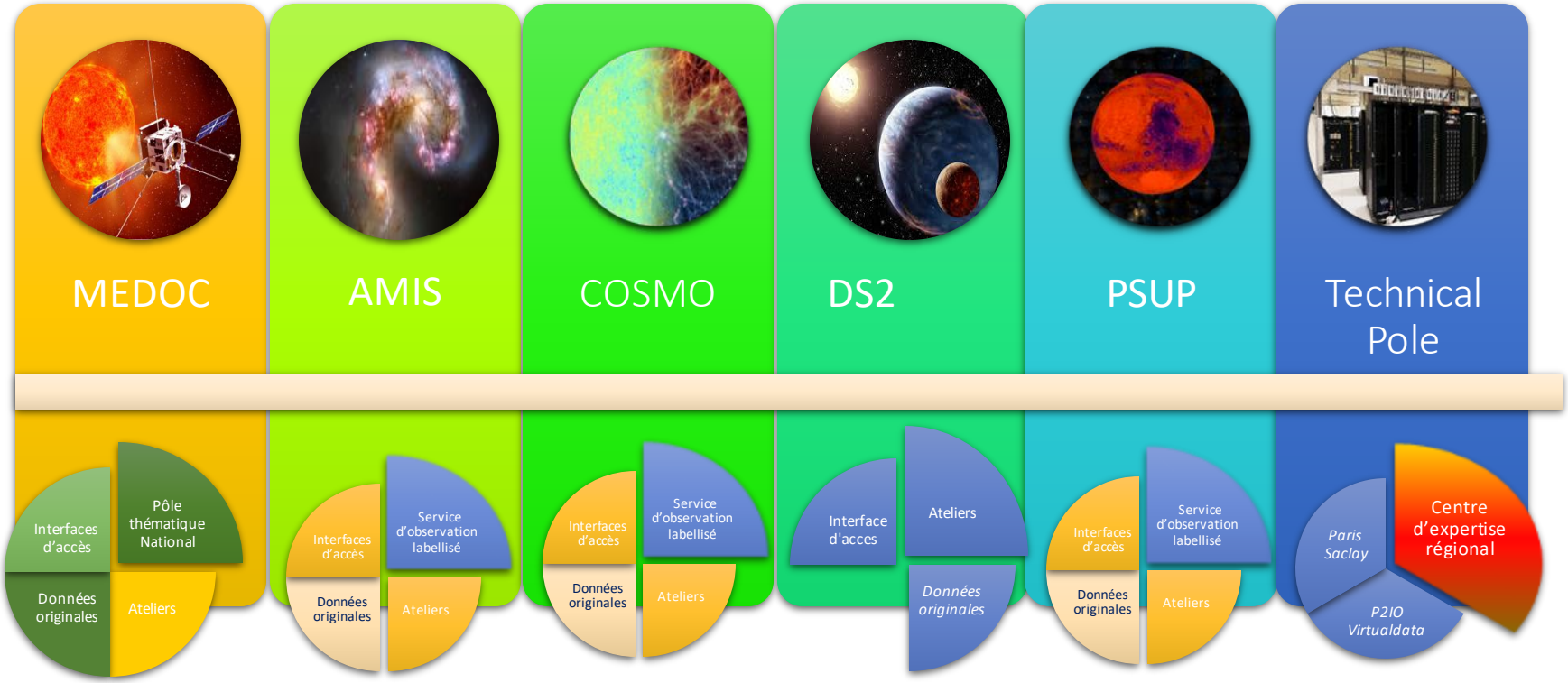
Supervisory authorities :

- Université ParisSaclay
- CNRS
- (CNES)

Funding sources :

- INSU, Université Paris Saclay, Conseil général,…
- CNES, Europe, Space Agencies,
- Average annual budget: >2 M€ (with staff)

IDOC : Ambitions



Ensure existing services and enable the emergence and visibility of new instrumental and observation services

Continue/Advance: Be recognized by a growing community as a center of expertise in supporting space missions, interpretation, access and preservation of their data

Allow a positioning for future missions

Strategy : Enhance capabilities with mutualization

- **Investments** — Pooled investments : Improved profitability spendings
- **Standardization** — Staff better efficiency
- **Human ressources** — Increased skills
- **Tools & developments** — ie: Sitools/REGARDS (CNES) for all interfaces: shared development
- **Infrastructure ressources** — No unnecessary duplicates & secure services

Convince all stakeholders to validate and support the strategy
strategy that has made it possible for IDOC to meet its commitments.

IDOC : Governance

IDOC is structured around 3 components:

1. Governance, management :
- Steering Committee.
- Scientific Manager.
- Technical Manager
- Coordinators of the different themes

Governance of IDOC resulting from .
- The recommendations of the OSUPS Board of Directors
- Recommendations of the thematic steering committees

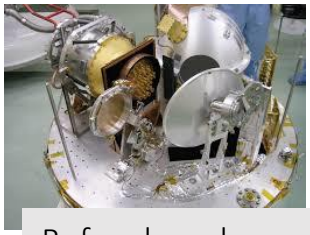
2. A technical pole

3. Autonomous scientific themes

The axes appoint a Scientific Coordinator to represent them in the IDOC steering committee

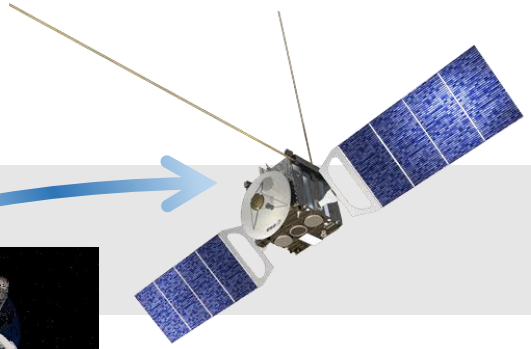
Note: MEDOC as a national thematic pole has its own steering committee and user committee

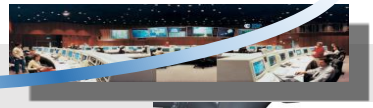
What types of projects



Before launch

0) Instruments conception & tests





1) Instrument Operations

Ground Segments

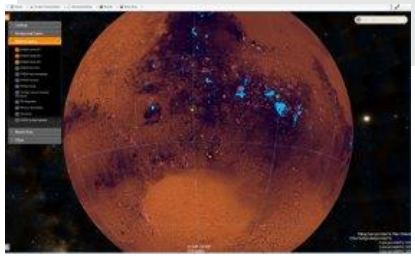
External data providers

2) Pipelines

3) Datasets, interfaces, tools, virtual observatories

Data Centers

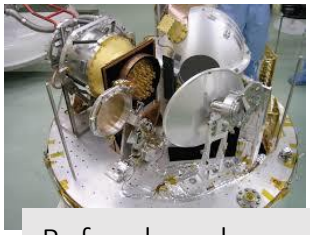
4) Medium & long term Archive



Outreach

Scientific community

What types of projects



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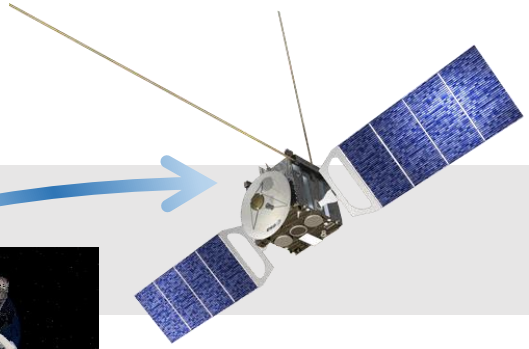
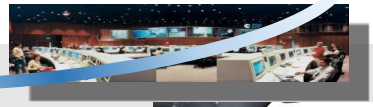
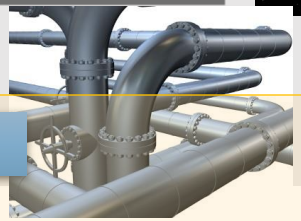




1) Instrument Operations

External data providers

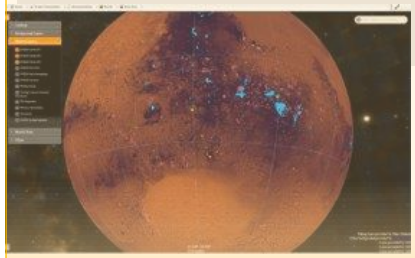
Ground Segments



2) Pipelines

Data Centers

3) Datasets, interfaces, tools, virtual observatories



4) Medium & long term Archive

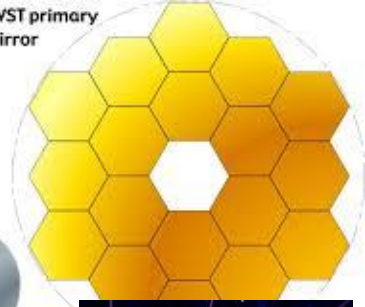
Scientific community

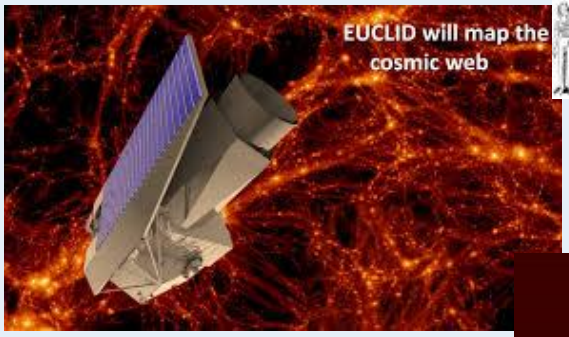
Outreach

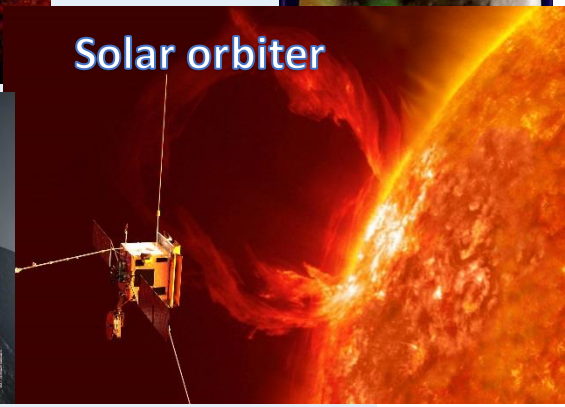
CoreTrustSeal certification

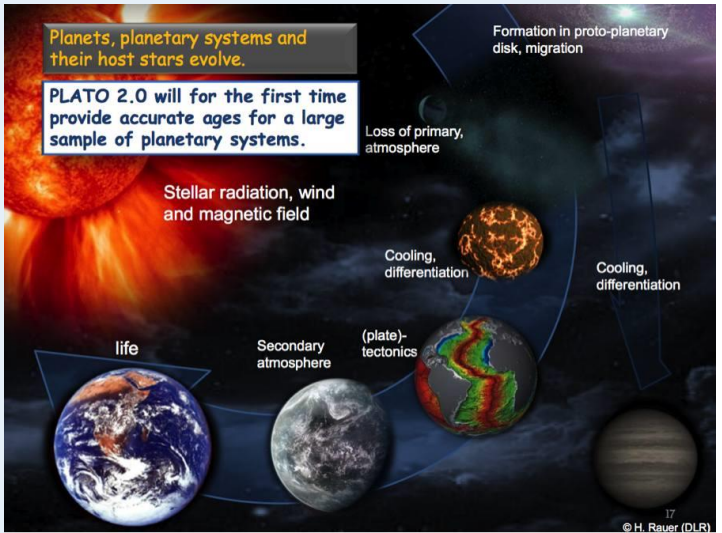
International space programs

- In préparation : WST, Euclid, Plato, Juice, Bepi-Colombo, Jovial, Exomars..
- Ongoing operations : Mars-express, SoHo, Stereo, SDO, Solar Orbiter
- Under treatment : Rosetta, CoRot, Planck, Herchel, Trace, Coronas, Picard, Iras

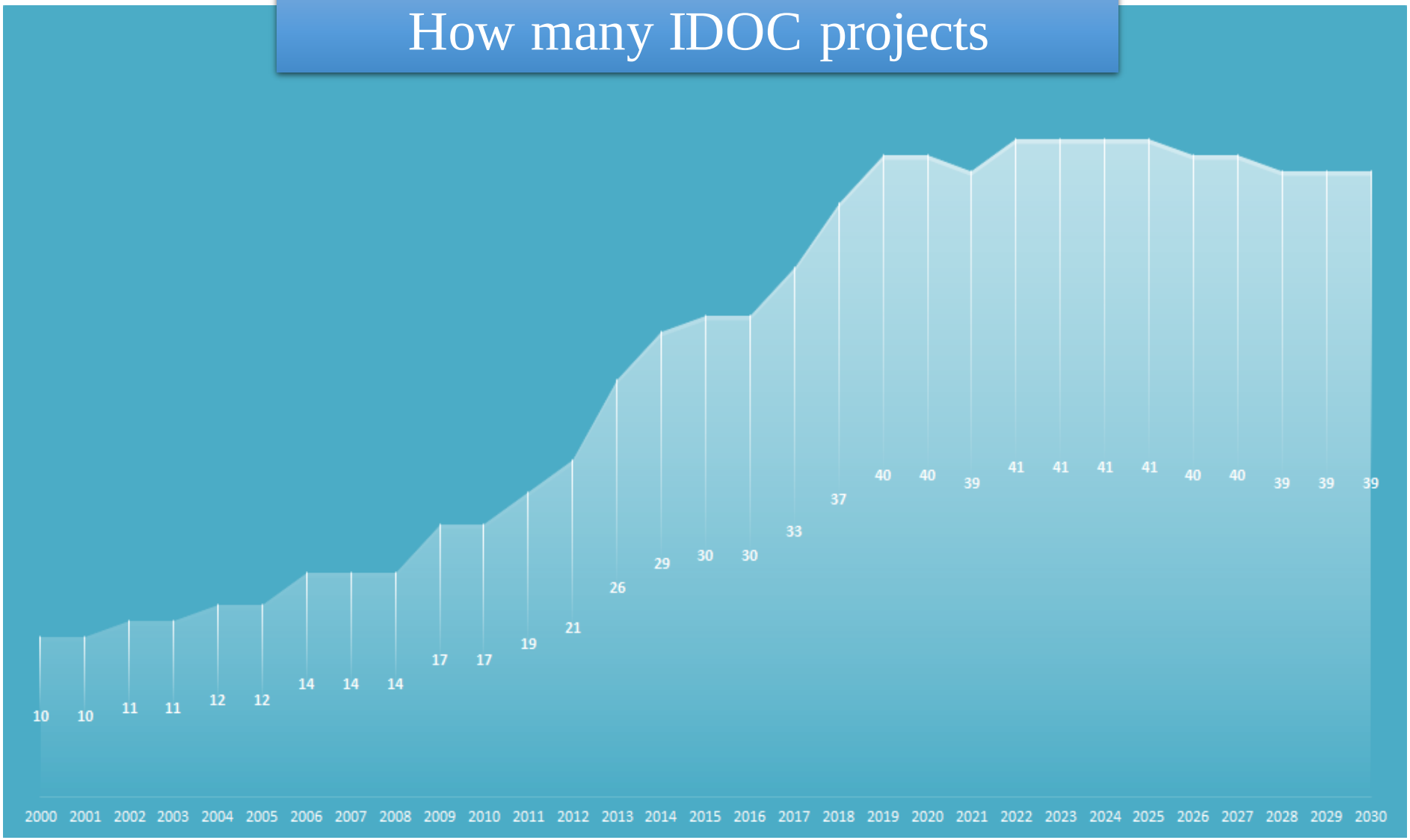






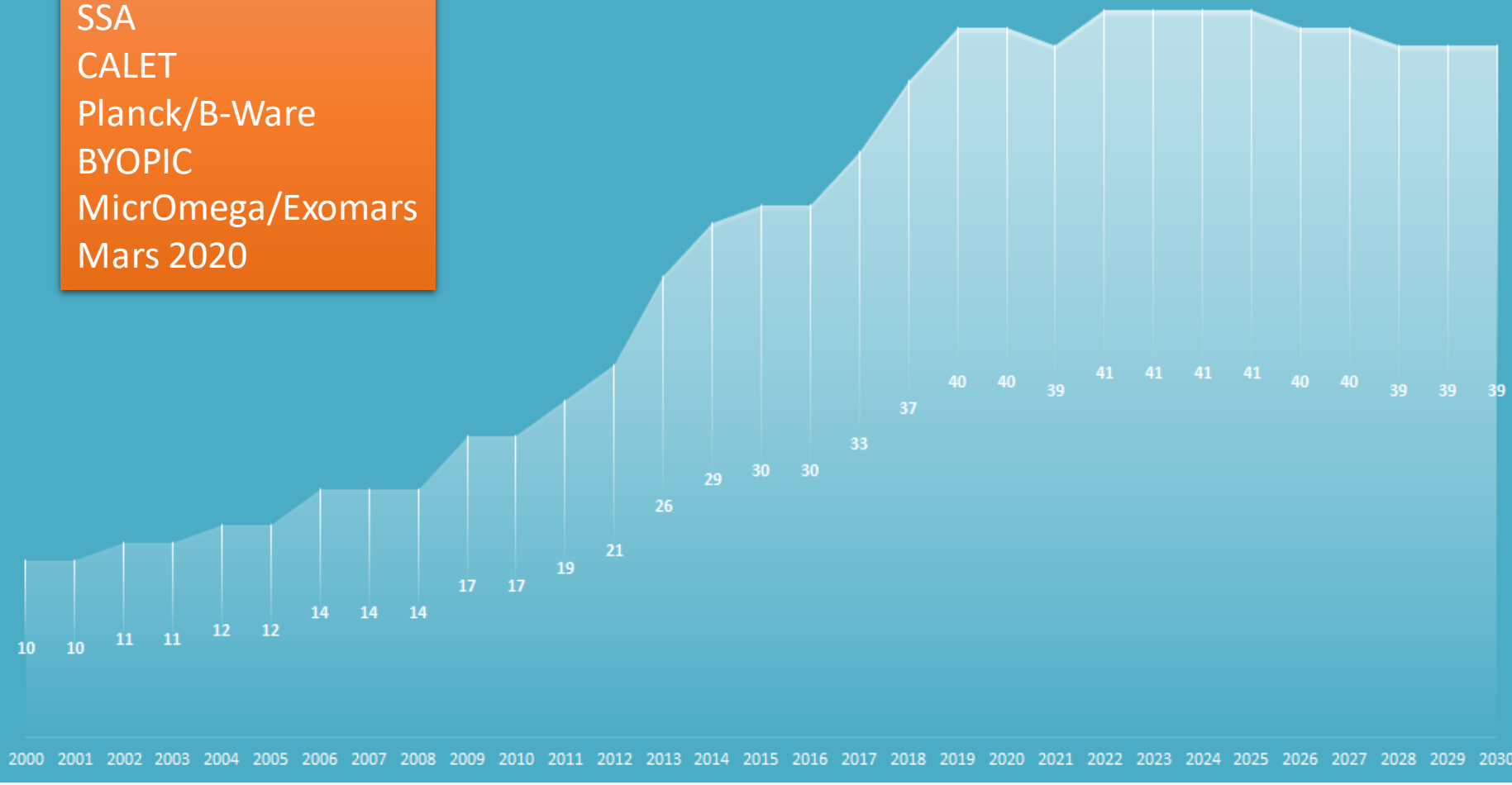


How many IDOC projects



How many IDOC projects

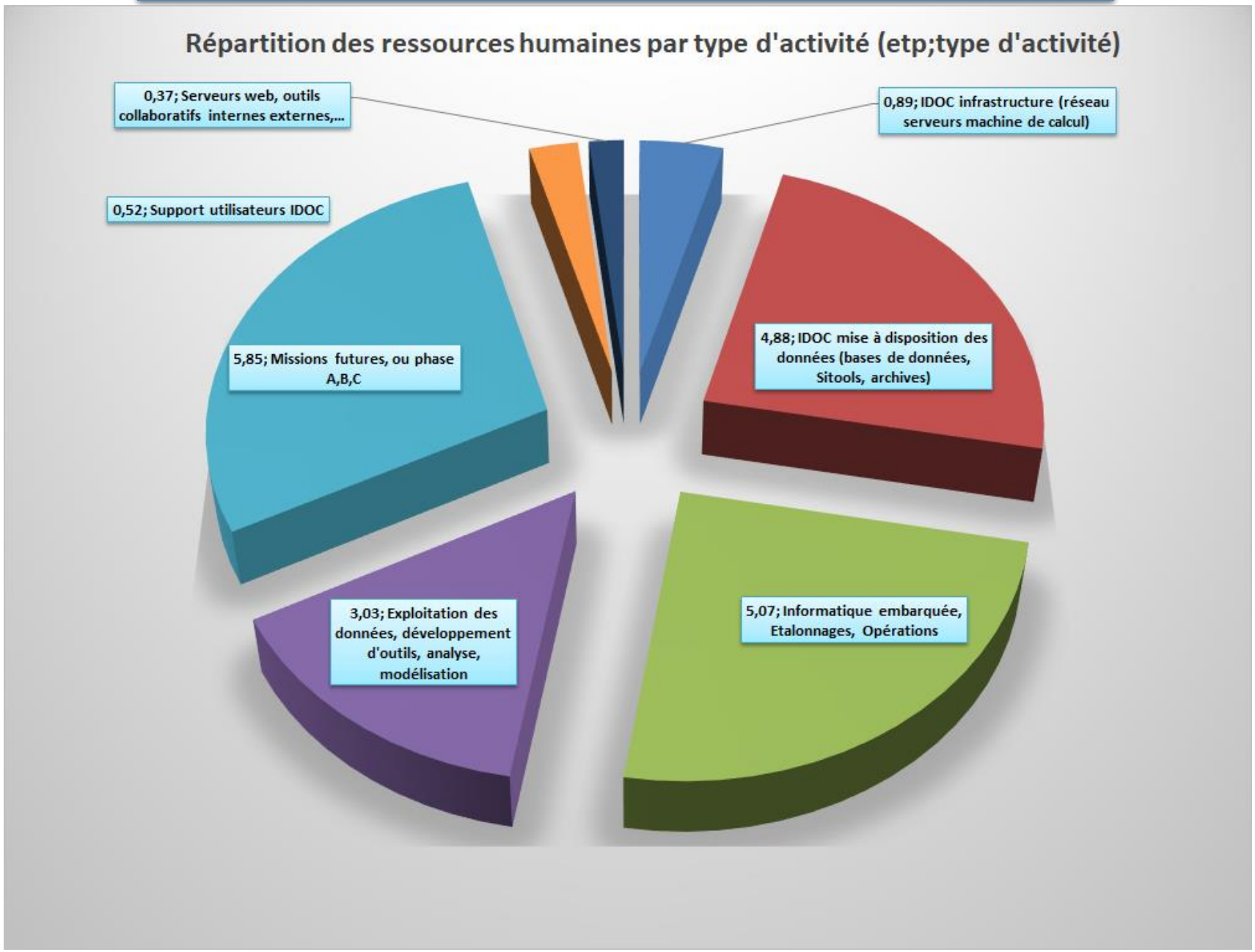
Jovial
SSA
CALET
Planck/B-Ware
BYOPIC
MicrOmega/Exomars
Mars 2020



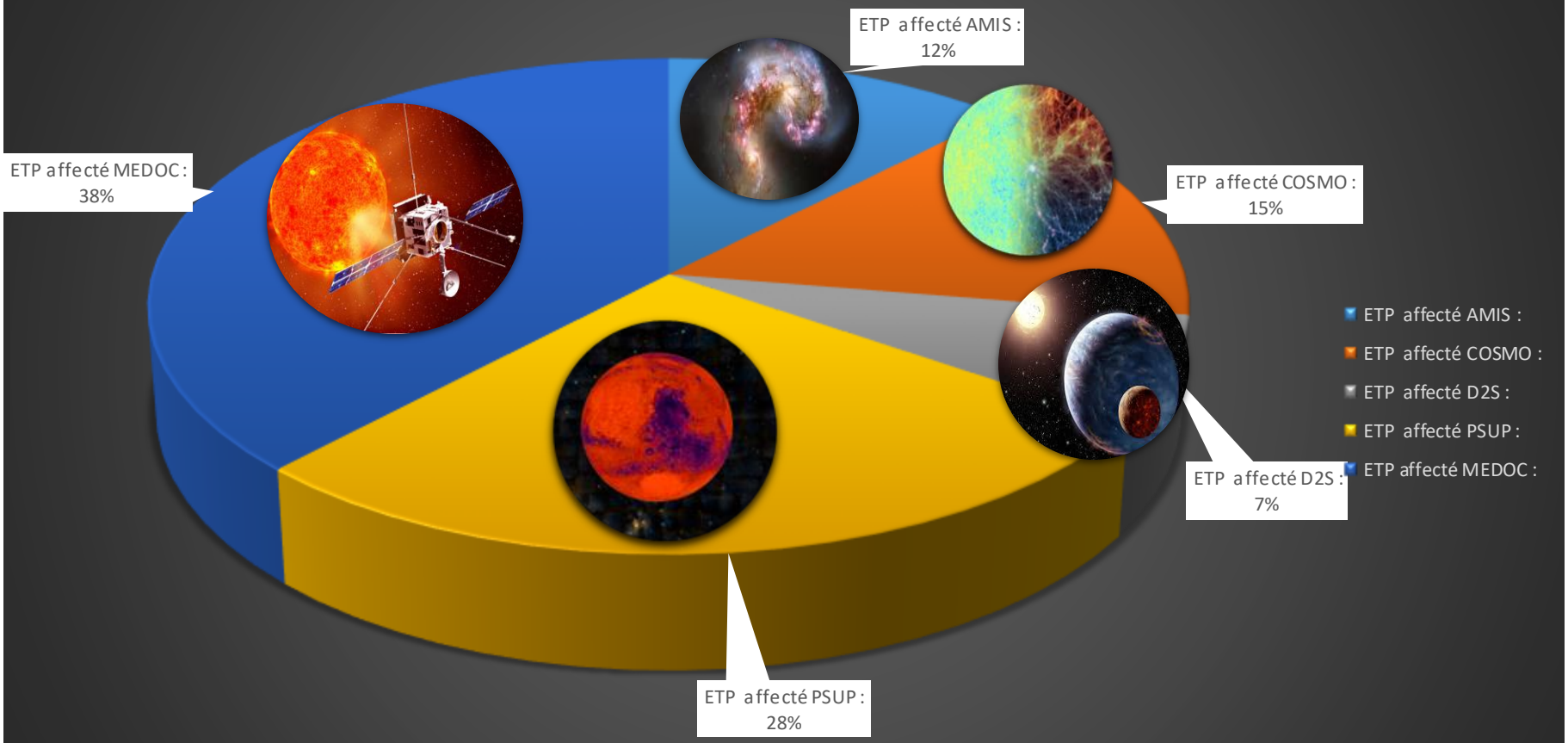
Budgets

Purchase value of the infrastructure taking into account the IAS share in the mutualisations	1 888,50 €	K€
Total repurchase value of mutualized infrastructure	5 060,50 €	K€
Average annual budget with staff	**2 159,10 €**	**K€**
Average annual budget without permanent staff	899,1	K€
Annual funding	2 159,12 €	K€
Annual funding without permanent staff	899,12	K€
Annual recurrent funding	512	K€
Non recurrent smoothed funding	387,12	K€
Staff/operating ratio	**58%**	

Human resources : 8,6 permanents, 15,2 temporary



Distribution of human resources by scientific theme



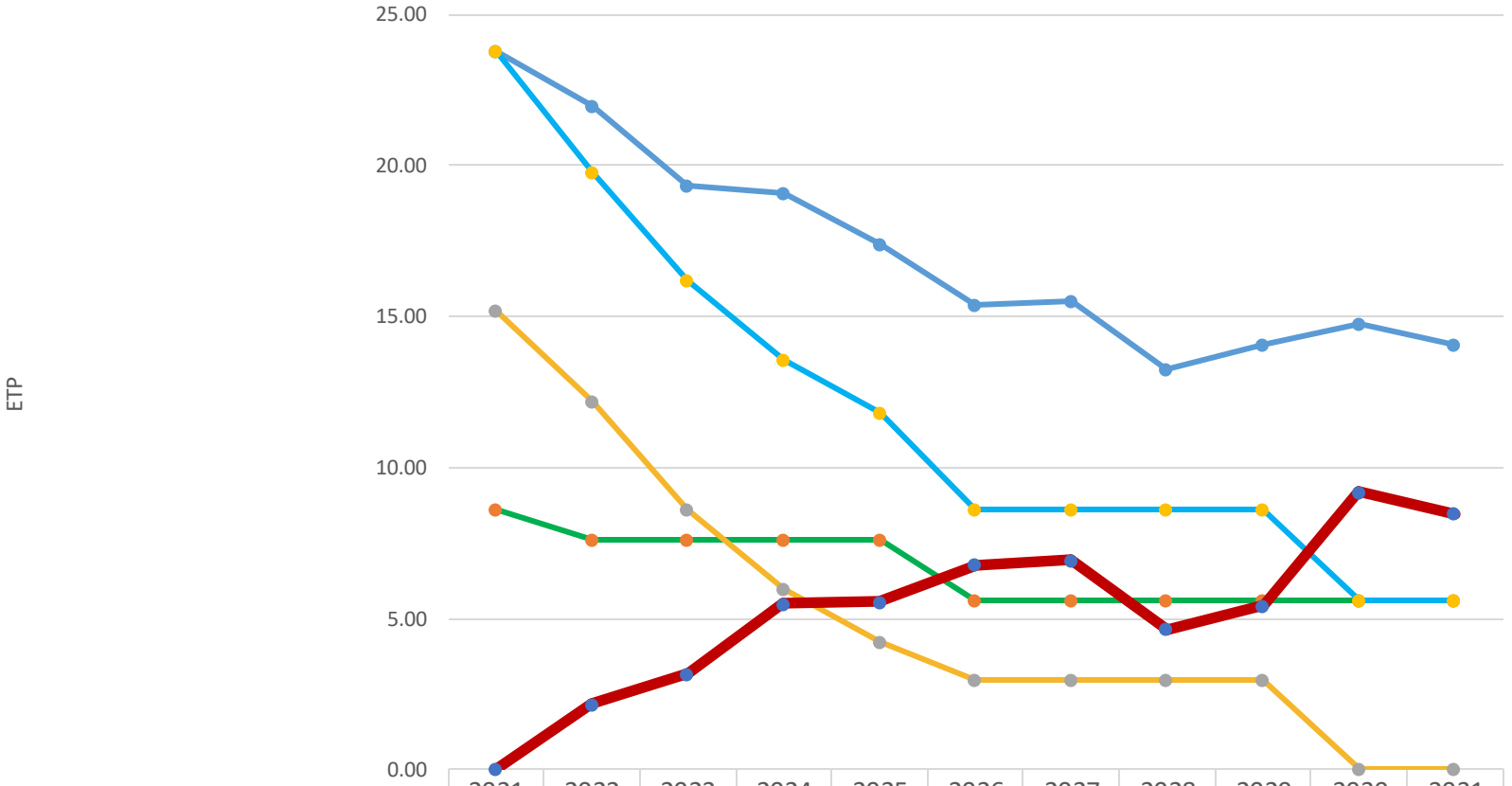
Human resources: Skills implemented

Information systems engineering	2,8 etp
Technical and production engineering	1,4 etp
Software engineering	15,4 etp
Scientific computing	1,4 etp

Project manager or expert in information systems engineering
Project manager or infrastructure expert
Application manager
Software architect
Software developer
Webmaster
Webdesigner
Big Data Engineer
Cloud Engineer
AI Engineer
Real Time Developer
Database administrator
Computer security expert
Information system consultant
IT support manager
Industrial computer scientist
IT Quality Engineer / IT Methods
…

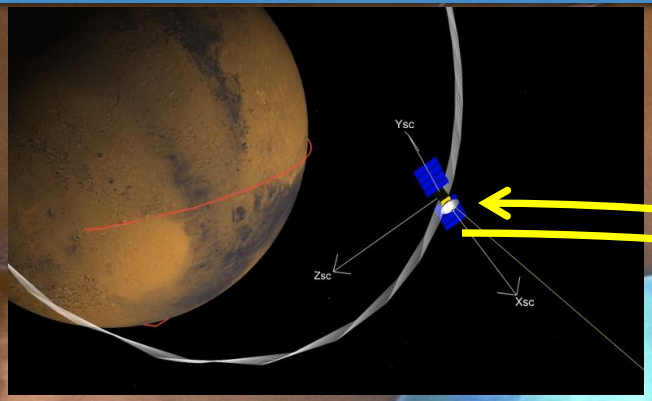
Human resources: currently, we have 1 permanent for ~= 2 temporary staff

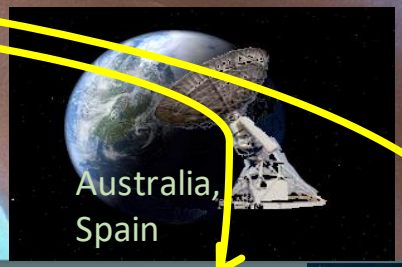
IDOC Human ressources: next 10 years



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total ETP requis (projets connus)	23.80	21.97	19.36	19.08	17.37	15.38	15.53	13.24	14.04	14.79	14.08
Permanents	8.6	7.60	7.60	7.60	7.60	5.60	5.60	5.60	5.60	5.60	5.60
Temporaires financés probables	15.20	12.20	8.60	6.00	4.20	3.00	3.00	3.00	3.00	0.00	0.00
Total Etp disponible	23.80	19.80	16.20	13.60	11.80	8.60	8.60	8.60	8.60	5.60	5.60
Déficit	0.00	2.17	3.16	5.48	5.57	6.78	6.93	4.64	5.44	9.19	8.48

IDOC : In-Flight Operations : OMEGA

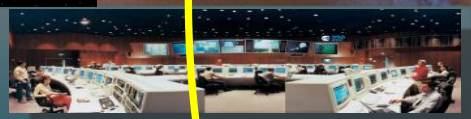




Ancillary Data

ESOC DDS Darmstadt

L0 Data



Telecommand validation

- APID packet routing
- Sort and update
- Decompression and checking
- PDS format
- Geometrical data computation
- Data delivery : Archiving,, Access control
- Data treatment

OMEGA Storage

L1 data
L2 data
L3 data

Omega : Orbit planning & TC generation

PDS Format, Validation

External access (dedicated CO-I interface)

ESAC Archive

IDOC operations and pipelines : OMEGA example

Solar position

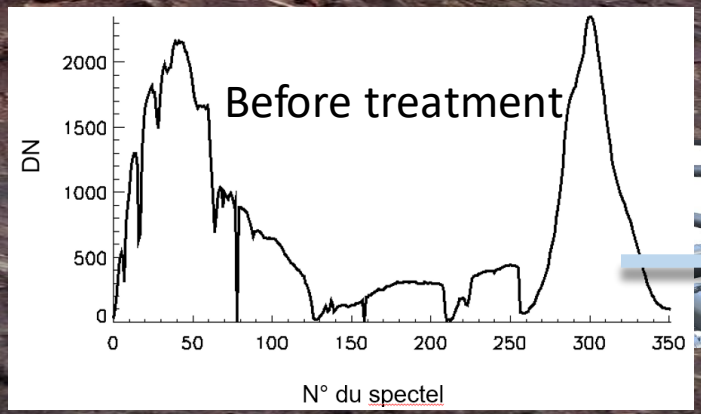
Satellite position

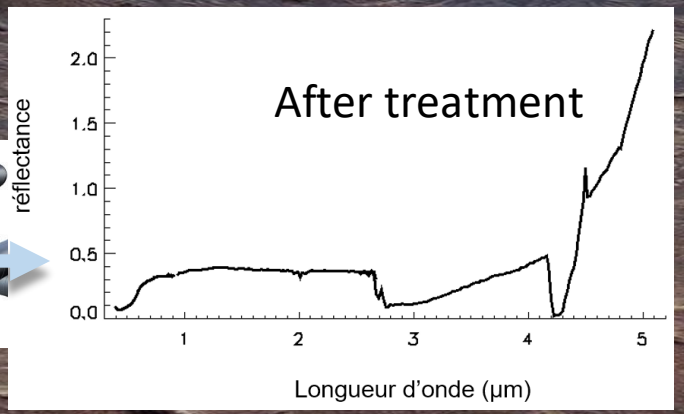
Displacement speed

Altitude
+

Ground topography

Fine ground texture

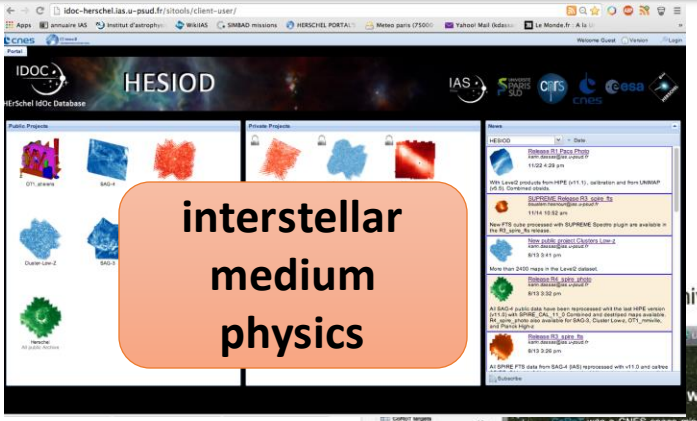




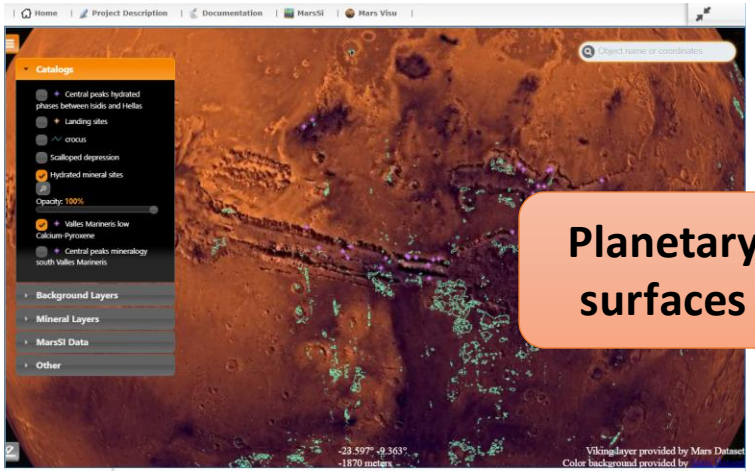
Datasets, interfaces, manipulation tools, virtuals observatories

CNES common tool
Sitools -> Regards
(First stable release,open source)

UWS
TAP
GeoJSON
faceted filtering.

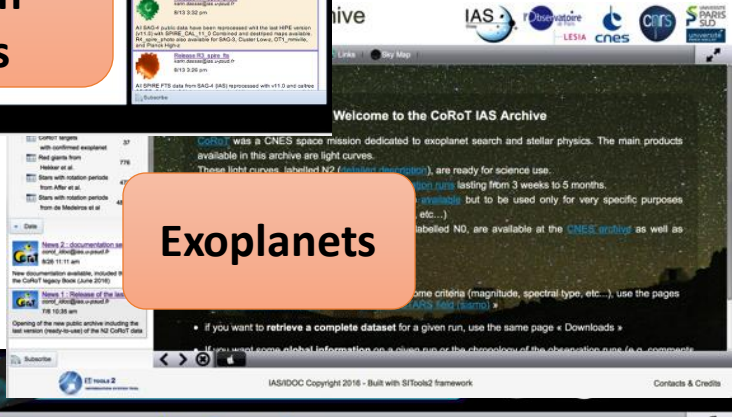


interstellar medium physics



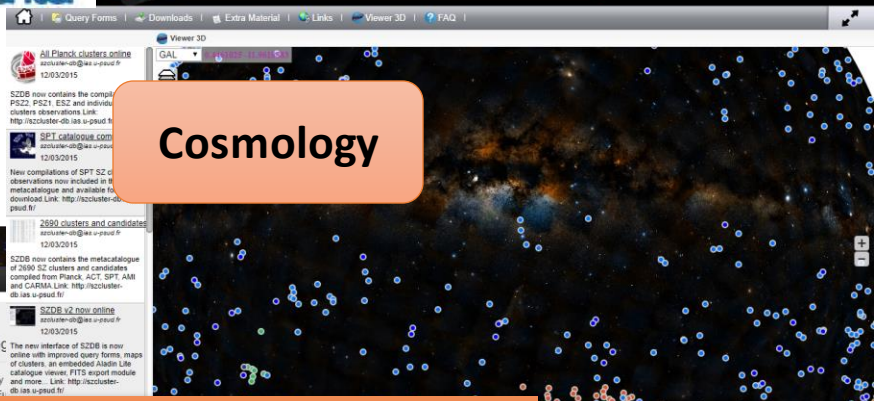
Planetary surfaces

IDOC
DataCenter



Exoplanets

Solar & Stellar physics



Cosmology

Open Science, FAIR data, OAIS standard, OV standards, DOIs

IDOC : Deliverables

23 instruments
7 Pipe-lines, level 0, 1, 2, 3
13 access portals
63 identified datasets (DOIs)

Community software

SUPREME (+Plug-in HIPE)
SITools2-Astronomy-Extension, ..

Numérical Codes (DOIs)

IRGal
DustEM
Modele 1D de vent solaire, ..

Sky surveys

Carte CO Planck
Carte opacité galactique Planck
Carte émission poussière Planck

Catalogs

Galaxy cluster Planck, ACT, SPT
Red giants Corot

On-the-fly calculation
on two sites (IAS and OCA)
UWS protocol

Simulations

IRGal
DustEM
Vent solaire 1D..

Observation data integrated within the OV

Base de données Herschel HESIOD
Base de données Corot
Base de données SOHO, Stereo, SDO, GAIA/DEM ..

Collaborations with other Virtual Observatories

Helioviewer mirror , Aladin mirror (CDS Strasbourg), ..
Ongoing : HELIO, Flarecast (FP7/H2020 european), Mizar (Planck), Propagation tool CDPP /IAS

IDOC : Delivrered

Total upload	2894 Go
Countries	124
Visits	80952
Visitors	38275
Pages	3224927
Hits	4908635
French pages	270477
French visitors	2737
French visitors/visitors ratio	7%

Important note: Accesses via virtual observatories or direct accesses (from a program) are currently not accounted (Regards?)

IDOC : prospective strategy and certification process

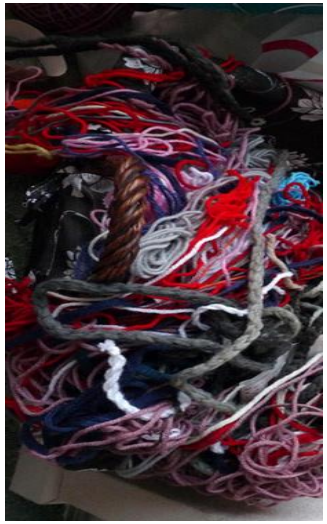
- Develop skills
- Respond to quality concerns.
- Gain in efficiency
- Strengthen visibility and confidence

#CodeClub

network of computer scientists : Regional, national

- OAIS
- ITIL guidelines
- Ongoing CoreTrustSeal certification
- DOIs (Digital Object Identifier) for each identified dataset

Durability of the data



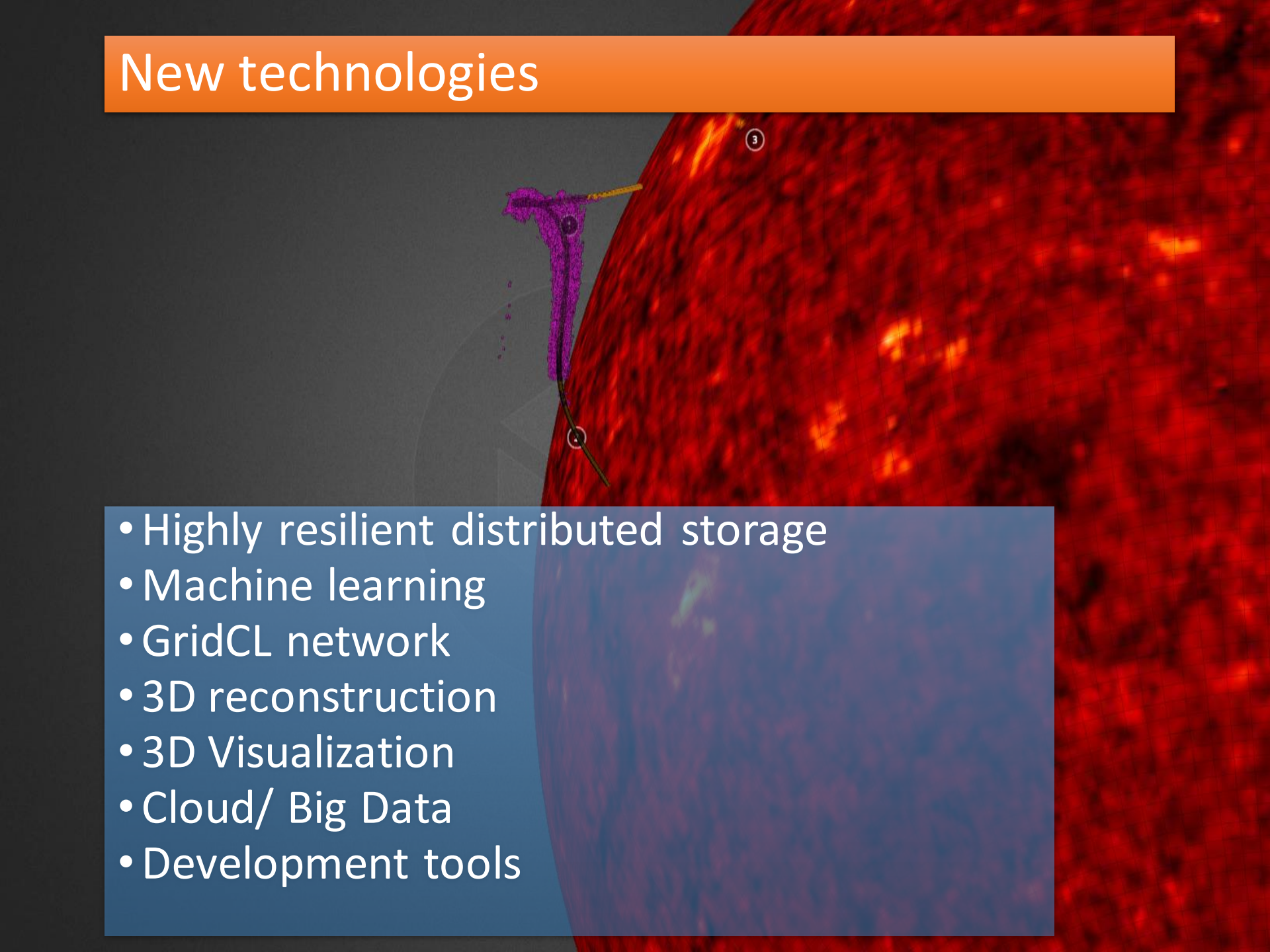
- Organize the content
- Ensure stability
- Organize the referencing
- Certify the origin
- Describe the context precisely
- Long term data curation

Specificities of the space domain

- Data sometimes impossible to reproduce
- Volumetrics : number of files or records
- Complex formats (Jpeg2000) or specific formats (PDS, FITS,..) : convergence (HDF5,..)
- Preserve the scientific use

IDOC
1 petabytes 2015
4 petabytes 2018
2025 ? 2035 ?

New technologies

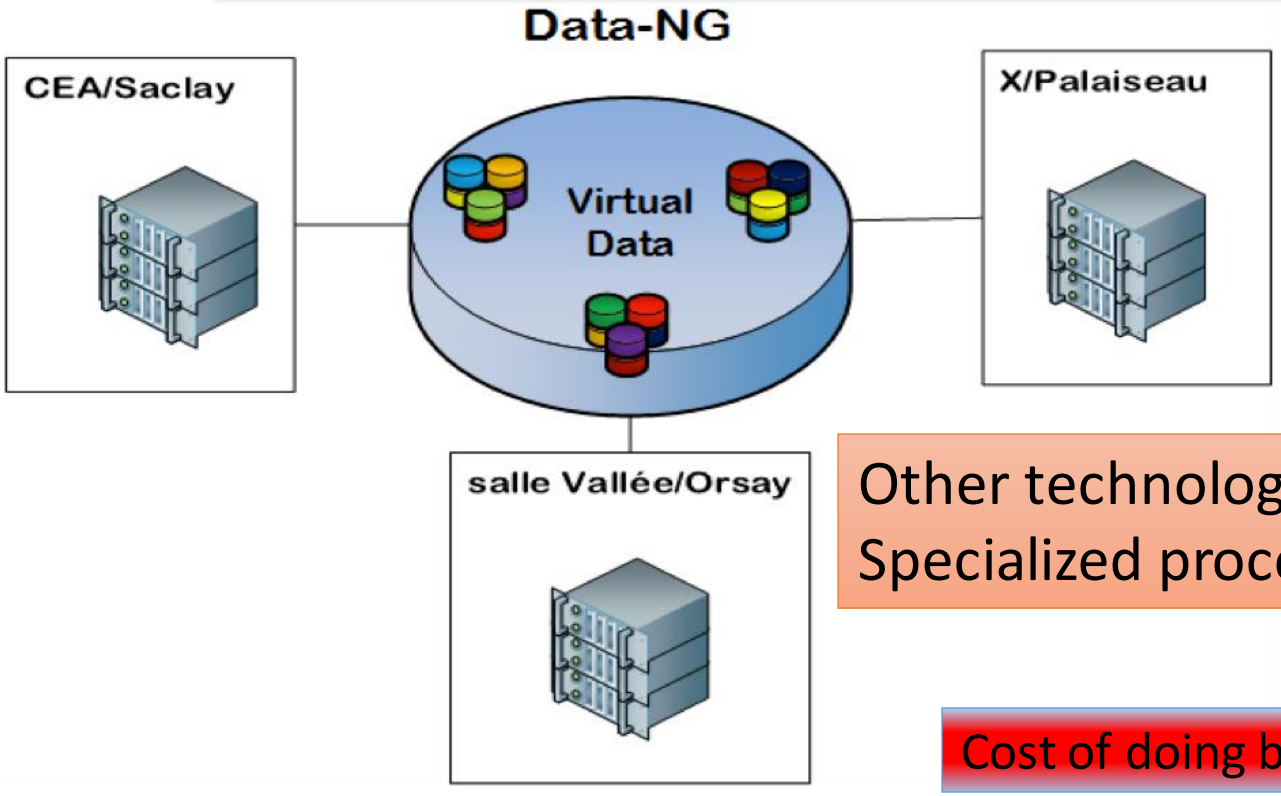


- Highly resilient distributed storage
- Machine learning
- GridCL network
- 3D reconstruction
- 3D Visualization
- Cloud/ Big Data
- Development tools

Example of a technological leap: P2IO distributed storage architecture

IDOC is a pioneer in these technologies

- CEPH for virtualization at IDOC since 2015
- CEPH for distributed storage in early 2017
- Cloud OpenStack (+450K€ Common IJCLab/Virtualdata 2021)
- Machine learning Deep learning



Other technological leaps to come.
Specialized processors ?

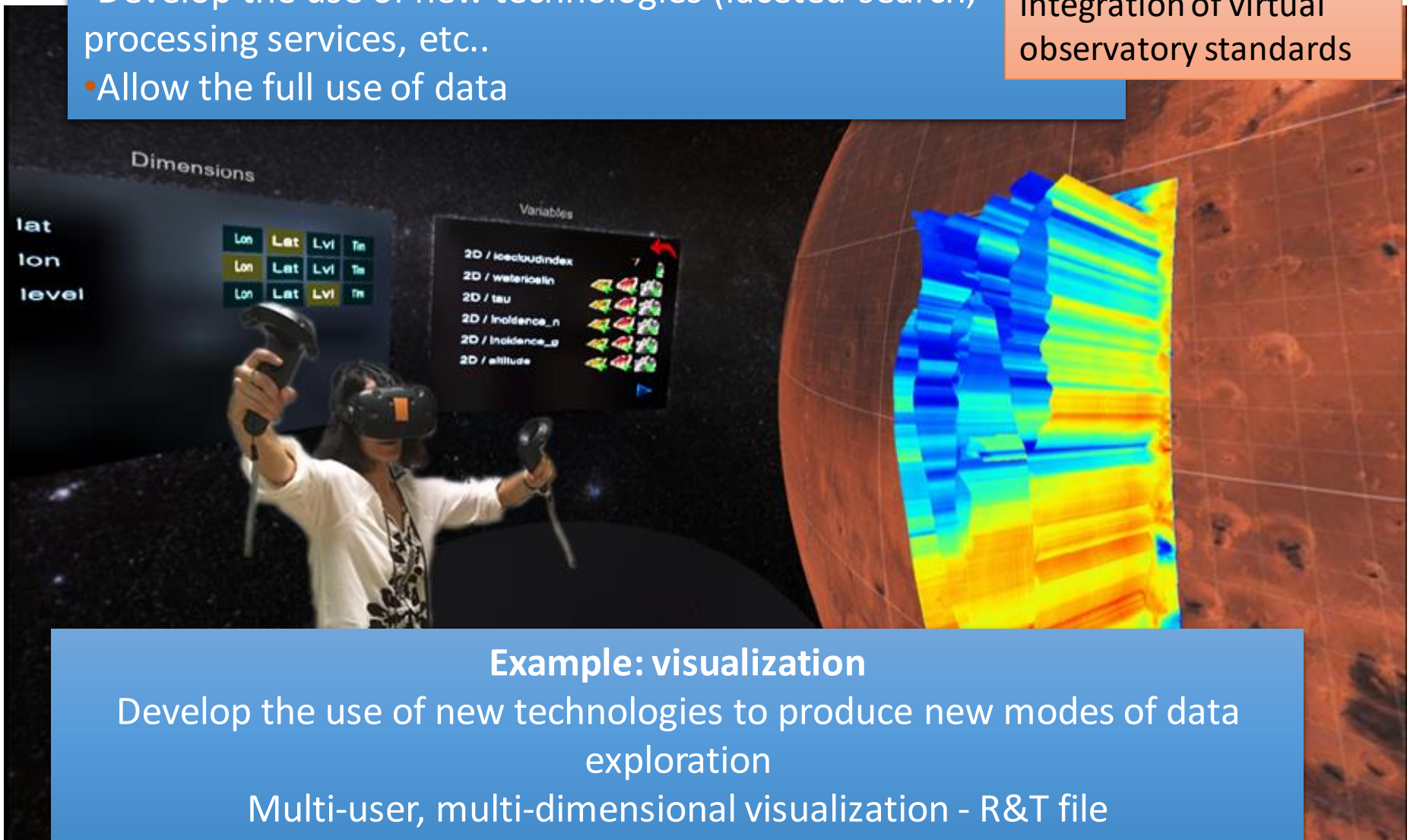
Cost of doing business

Projects and software: trends

Accès aux données :

- Easily aggregate new types of data (data cubes, models, etc.)
- Develop the use of new technologies (faceted search, processing services, etc..
- Allow the full use of data

Integration of virtual observatory standards



Example: visualization

Develop the use of new technologies to produce new modes of data exploration

Multi-user, multi-dimensional visualization - R&T file

Development tools

Integration of a complete range of "Quality" tools

- Project management
- Intelligent development assistance

Gestion documentation

Redmine

Gitlab

Jenkins

Gitlab-CI

Intégration continue

Gestion de tickets

Redmine

Gitlab

Nexus

Référentiel d'artefacts

Gestion de version

svn

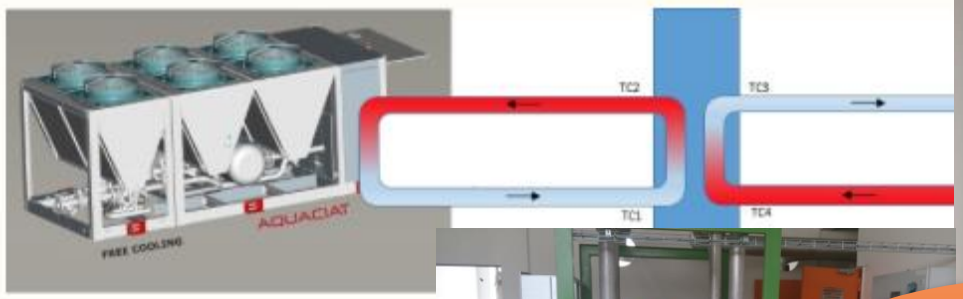
Gitlab

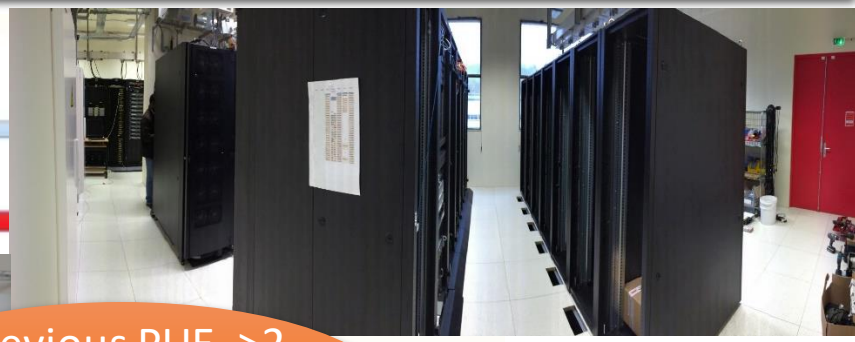
Sonarqube

Analyse qualité

P2IO " Valley " room
IDOC virtualdata incentive incubator

- Feasibility study conducted in late 2012
- Initial implementation 2013
- Joint development of competence networks
- Governance documents
- 500 physical servers, 8000 cores, 5 PB of data
- Expansion x2 completed 2020





Previous PUE >2
Reached PUE :
< 1,3

Global budget 1st phase 1M€.
2nd phase : 2,3 M€.
Return on investment: 3 years

Level of service and cost-effectiveness impossible to achieve without mutualization.

IDOC : achievements

- IDOC includes MEDOC which is the "Thematic Pole of Solar Physics" (partnership agreement between CNES, INSU, and the University of Paris-Saclay)
- IDOC is at the heart of the "planetary surfaces" pole resulting from the reflection of the PNP
- IDOC is the mission center of the SPICE instrument of the Solar Orbiter mission and will be the mission center of
  - the Majis instrument of the JUICE mission
  - the Plato mission.
- IDOC is the driving force behind the development of the Sitools framework and its successor REGARDS under CNES project management, which is at the heart of the access interfaces.

Creation 01/01/2005,
Certification as a regional competence center: 01/01/2014
Certification as a long-term spatial data archiving center: September 2016
INSU platform: summer 2018
CoreTrustSeal Certification: in progress